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IP/2004/050885

US 030168

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September 02, 2003

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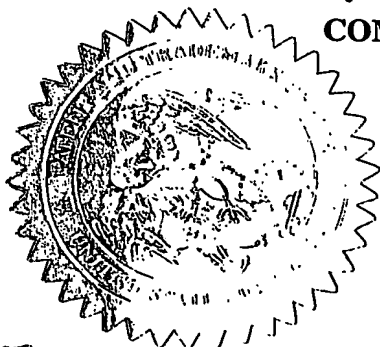
APPLICATION NUMBER: 60/478,156 ✓

FILING DATE: June 12, 2003 ✓

## PRIORITY DOCUMENT

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*L. Edelen*

L. EDELEN  
Certifying Officer

06-13-03 60478156 .061913/pe

## PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(b)(2).

Docket Number <b>US030168</b>		Type a plus sign (+) inside this box <input type="checkbox"/>	+
INVENTOR(s) / APPLICANT(s)			
LAST NAME	FIRST NAME	MIDDLE INITIAL	RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY)
<b>DEL PRADO SHANKAR</b>	<b>JAVIER SAI</b>		<b>OSSINING, NY TARRYTOWN, NY</b>
TITLE OF THE INVENTION (280 characters max)			
<b>METHOD TO INCREASE THROUGHOUT EFFICIENCY VIA FRAME AGGREGATION IN 802.11 WLAN</b>			
CORRESPONDENCE ADDRESS			
Corporate Patent Counsel U.S. Philips Corporation P.O. BOX 3001 BRIARCLIFF MANOR, NY 10510			
STATE	New York	ZIP CODE	10510 COUNTRY U.S.A.
ENCLOSED APPLICATION PARTS (check all that apply)			
<input checked="" type="checkbox"/> Specification	Number of Pages	<input type="checkbox"/> Small Entity Statement	
<input type="checkbox"/> Drawing(s)	Number of Sheets	<input type="checkbox"/> Other (specify)	
METHOD OF PAYMENT (check one)			
<input type="checkbox"/> A check or money order is enclosed to cover the Provisional filing fees		PROVISIONAL FILING FEE AMOUNT (\$)	160.00
<input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number: 14-1270			

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒

No

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Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

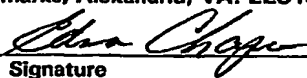
SIGNATURE:

Date: June 12, 2003TYPED or PRINTED NAME: STEVEN R. BIRENREGISTRATION NO.: 26,531☐

Additional inventors are being named on separately numbered sheets attached hereto

**CERTIFICATE OF EXPRESS MAILING**Express Mail Mailing Label No. EV 335 816 778Date of Deposit: June 12, 2003

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Signature

## INVENTION DISCLOSURE (continued)

### Introduction

IEEE 802.11 Medium Access Control (MAC) [3] operates on 2 bands (namely 2.4 GHz and 5.0 GHz) and operates with 5 different physical layers namely, DSSS, FHSS, IEEE 802.11a PHY, IEEE 802.11b PHY and IEEE 802.11g PHY. All the PHYs excepting IEEE 802.11a operate in the 2.4GHz band while IEEE 802.11a operates in the 5 GHz band. The most popular among those PHYs are IEEE 802.11a [5] and IEEE 802.11b [4]. The standard specification for the physical layer specifies on how a MAC frame is transmitted over the air after adding the overheads. We will describe in brief on how the frame is processed before being transmitted in the air.

1. When a data frame arrives from the higher layer, the MAC adds the MAC layer header including the Transmitter address, Receiver address and the MAC layer CRC known as Frame Control Sequence (FCS).
2. After this the MAC determines the physical layer rate at which this frame is to be transmitted in the air and passes the frame to the physical layer. At this layer the frame is added with physical layer control procedure (PLCP) header and a preamble before being transmitted in the air.

The transmission time of the PLCP preamble is 16 microseconds for IEEE 802.11a/g and 144 microseconds for IEEE 802.11b. The PLCP header is also transmitted using the basic rate and its transmission time is also fixed. They are 4 microseconds for IEEE 802.11a/g and 44 microseconds for IEEE 802.11b.

Recently IEEE 802.11e introduced the concept of transmission opportunity (TXOP). By this, the non-AP QSTA and QAP contend the medium for time and once they get access to the channel they can hold the channel for the time specified by TXOPlimit and transmit multiple frames with spaced by SIFS. This is called TXOP bursting. But for each frame transmission during the bursting a fixed overhead of 20 microseconds for IEEE 802.11a/g and 192 microseconds for IEEE 802.11b is wasted in terms of transmitting the preamble and PLCP header. When the IEEE decided to introduce the new MAC study group, IEEE 802.11n, this preamble posed a stumbling block in increasing the efficiency of the MAC. So we propose the following methods and new IFS namely the Burst Inter Frame Space (BIFS) time.

### Invention 1: Burst Inter Frame Space Time (BIFS)

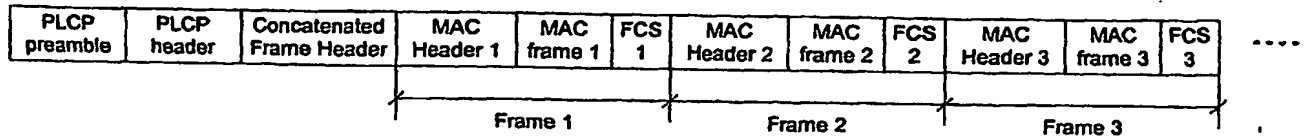
IEEE 802.11e draft specifies that during a TXOPlimit, a non-AP QSTA/QAP may use the no ACK or block ACK policy. By no ACK, each frame is transmitted and the ACK is not expected for that frame. If the TXOPlimit were larger than the single frame transmission time and if more frames are pending transmission at the MAC queue, the current IEEE 802.11e standard specifies that the succeeding frames may be transmitted after SIFS time. Similarly in the block ACK policy of IEEE 802.11e frames are transmitted successfully with IFS time SIFS before the transmission of the ACKs by the receiver. This SIFS time is actually required only if the receiving non-AP QSTA/QAP were to return an acknowledgement as it includes the time to process the frame plus the receiver (RX) to transmitter (TX) turnaround time. In case of no ACK as well as Block ACK policies it is not necessary to have the receiver wait for SIFS time to transmit the ACK frame (excepting for the last frame in the block ACK policy after which the receiver must send ACK to the transmitter). So we propose a new IFS called BIFS. So the frames that don't need ACK immediately are transmitted continuously with the BIFS time between frames. BIFS can be shorter than SIFS, since it does not include the Rx to Tx turnaround time, and it is only needed for the receiver to detect the end of one frame, and the beginning of the next one. This is shown in the following figures.

### Invention 2: Organizing the MAC frames

#### Method 2.a- Only one transmission of PLCP header and PLCP preamble

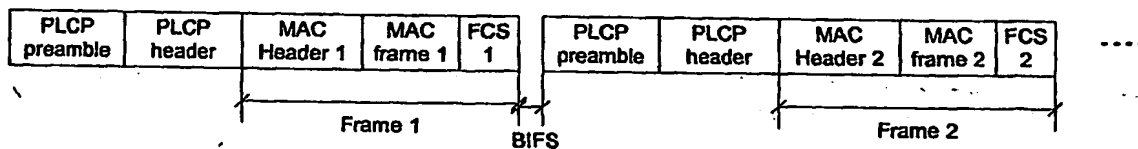
Let the transmitting MAC have multiple frames queued in its buffers. Instead of transmitting each frame with its PLCP header and preamble, the MAC transmits the PLCP header and preamble only once before the start of the frame transmission and then transmits remaining frames without the PLCP header or preamble. The PLCP preamble and header is used by all receivers. Each receiver decodes only the MAC frames addressed to itself. This is done with a new frame format called concatenated frame format (multiple frames packed into a single frame). The concatenated frame header provides information of the number of frames following the PLCP header and its length, so that the receivers know when the MAC frames start and end. This means except for the first frame the PLCP overhead is totally eliminated for the succeeding frames. If the MAC were to transmit 10 frames then the gain in overhead elimination would be  $9 \times \text{PLCPoverhead}$ . This method is similar to the container frame provided in IEEE 802.11e D1.0 and the train frame in HiperLAN/2 [6][7], however this new method allows for multiple transmitters/receivers in a single concatenated frame.

## INVENTION DISCLOSURE (continued)



## Method 2b- Multiple transmissions of PLCP header and PLCP preamble

In the case where the concatenated frame is too long it would be harmful for that frame if the channel state changes. Based on the estimation of the future channel state during the transmission of the concatenated frame the transmitting station may insert PLCP preamble after few frames so that the receiver using the channel state information from the preamble can extract the frame if the channel were to go bad during the transmission. The frames can be separated by BIFS, which is only big enough for the receiver to detect the end of the frame and the beginning of the next one.



- [1] IEEE 802.11e/D4.3, Draft Supplement to Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: Medium Access Control (MAC) Enhancements for Quality of Service (QoS), May 2003.
- [2] Sunghyun Choi, Youngsoo Kim, Hyosun Hwang and Kyunghoon Jang "Throughput Enhancement via Frame Aggregation," IEEE 802.11-03/376, May 2003.
- [3] IEEE Std. 802.11-1999, *Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications*, Reference number ISO/IEC 8802-11:1999(E), IEEE Std. 802.11, 1999 edition, 1999.
- [4] IEEE Std. 802.11b, *Supplement to Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-speed Physical Layer Extension in the 2.4 GHz Band*, IEEE Std. 802.11b-1999, 1999.
- [5] IEEE Std. 802.11a, *Supplement to Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-speed Physical Layer Extension in the 5 GHz Band*, IEEE Std. 802.11a-1999, 1999.
- [6] ETSI, "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) layer; Part 1: Basic Data Transport Functions," Technical Specification, ETSI TS 101 761-1, V1.1.1, April 2000.
- [7] ETSI, "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) layer; Part 4: Extension for Home Environment," Technical Specification, ETSI TS 101 761-4, V1.2.1, August 2000.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
In re Application of Atty. Docket

JAVIER DEL PRADO ET AL

US 030168

Serial No.

Filed: CONCURRENTLY

Title: METHOD TO INCREASE THROUGHOUT EFFICIENCY VIA FRAME.  
AGGREGATION 802.11 WLAN

Commissioner for Patents  
Alexandria, VA 22313

APPOINTMENT OF ASSOCIATES

Sir:

The undersigned Attorney of Record hereby revokes all prior appointments (if any) of Associate Attorney(s) or Agent(s) in the above-captioned case and appoints:

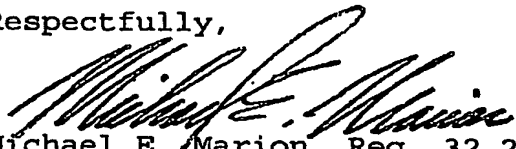
STEVEN R. BIREN

(Registration No. 26,531)

c/o U.S. PHILIPS CORPORATION, Intellectual Property Department, 580 White Plains Road, Tarrytown, New York 10591, his Associate Attorney(s)/Agent(s) with all the usual powers to prosecute the above-identified application and any division or continuation thereof, to make alterations and amendments therein, and to transact all business in the Patent and Trademark Office connected therewith.

ALL CORRESPONDENCE CONCERNING THIS APPLICATION AND THE LETTERS PATENT WHEN GRANTED SHOULD BE ADDRESSED TO THE UNDERSIGNED ATTORNEY OF RECORD.

Respectfully,

  
Michael E. Marion, Reg. 32,266  
Attorney of Record

REC'D 14 JUN 2004

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January 28, 2004

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APPLICATION NUMBER: 60/529,588 ✓

FILING DATE: December 15, 2003 ✓

## PRIORITY DOCUMENT

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*T. Wallace*  
T. WALLACE  
Certifying Officer

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12/18/2003 MBELETE1 00000112 141270 60529588

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This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EV 312 068 652

Date of Deposit: December 15, 2003

INVENTOR(S)					
Given Name (first and middle [if any])		Family Name or Surname		Residence (City and either State or Foreign Country)	
JAVIER SAI SHANKAR		DEL PRADO NANGADOPALAN		OSSINING, NEW YORK TARRYTOWN, NEW YORK	
<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (280 characters max)					
CONCATENATED FRAME STRUCTURE FOR DATA TRANSMISSION					
CORRESPONDENCE ADDRESS					
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<input checked="" type="checkbox"/> Customer Number 24737 → <b>24737</b>					
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Address		P.O. BOX 3001			
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City		BRIARCLIFF MANOR		State	NEW YORK
Country		USA	Telephone	(914) 333-9608	Fax (914) 332-0615
ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages		10		<input type="checkbox"/> CD(s), Number	
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets		4		<input type="checkbox"/> Other (specify)	
<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)					
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.					
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees.					
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FILING FEE AMOUNT (\$) 160.00					
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
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Respectfully submitted,

SIGNATURE

Date

12/15/03

TYPED or PRINTED NAME

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(914) 333-9608

Docket Number:

US030168

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This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Box 1450, Alexandria, VA 22313-1450

# **CONCATENATED FRAME STRUCTURE FOR DATA TRANSMISSION**

## **Related Applications**

This application claims priority to U.S. Provisional Applications Serial Nos.  
5 60/478,156 filed on June 12, 2003, and 60/487,694 filed on July 16, 2003, the entire disclosures of which are hereby incorporated by reference.

## **Technical Field of the Invention**

The present invention relates to data transmission techniques, and more  
10 particularly, to an optimized method for efficiently transmitting data frames using MAC protocols, such as wireless IEEE 802.11 protocol. The present invention also relates to a novel frame structure used in the inventive method.

## **Background of the Invention**

15 The IEEE 802.11 wireless data network standard defines a Media Access Control (MAC) layer and a Physical (PHY) layer for a data network with wireless connectivity. The specification for the physical (PHY) layer specifies on how a MAC frame is transmitted over the air after adding the overheads. When a data frame arrives from the higher layer, the MAC adds the MAC layer header including  
20 addresses of the transmitter and the destination (receiver), as well as the MAC layer CRC (Cyclic Redundancy Check) known as Frame Control Sequence (FCS). Thereafter, the MAC determines the physical layer rate at which this frame is to be transmitted in the air and passes the frame to the physical layer. At this layer the frame is added with a physical layer control procedure (PLCP) header and a preamble

before being transmitted in the air. The conventional frame structure is shown in Figures 1 and 2.

Figure 1 illustrates a typical frame format of data frames for transmission according to IEEE 802.11 protocol. Each frame typically comprises two parts. One is a PLCP overhead 10, which includes a PLCP preamble portion 11 and a PLCP header portion 12, and the other is a MAC data frame 20, which includes a MAC header portion 21, a MAC frame body portion 22 and a CRC portion 23.

The PLCP preamble 11 is PHY dependent, which includes information mainly used for timing and synchronization functions. The PLCP header 12 mainly includes information about the length of the frame, the transmission rate, etc.

The MAC data frame 20 is illustrated in more detail in Figure 2. The MAC header

Portion 21 includes addresses information 214 and other information, such as Frame Control 211, Duration/ID 212, Sequential Control 213, etc. The MAC layer CRC portion 23 is known as Frame Control Sequence (FCS).

The PLCP overhead 10 is always transmitted at the lowest transmission rates in today's IEEE 802.11 systems. Specifically, the fixed transmission time is 20 microseconds for IEEE 802.11a and 802.11g and is 192 microseconds for IEEE 802.11b. According to the current IEEE 802.11 standard, the maximum size of the MAC frame is 2304 bytes, and each MAC frame is added with the PLCP overhead 10, which substantially decreases the network throughput. Moreover, because of high error rates in wireless networks, the frames may be even fragmented into smaller fragments, and each fragment will have the above said PLCP overhead 10.

Each MAC data frame 20 has a MAC header 21 that includes address information 214 indicating the destination. According to the current MAC protocols

such as IEEE 802.11, the address information 214 is included in the MAC header 21 in all the MAC data frames 20 even though they are transmitted to the same destination. This does not lead to an optimized throughput efficiency.

Therefore, there is a need in the art an improved method which is more efficient in transmission of MAC data frames over a data network.

### Summary of the Invention

In one aspect, the present invention provides a new method of transmitting data frames over a data network. In particular, according to the present invention, a plural number of MAC (Media Access Control) data frames are transmitted with only a single PLCP (Physical Layer Control Procedure) overhead 10. Because only one PLCP overhead 10 is transmitted with the plurality of MAC data frames, the network throughput and efficiency is considerably increased.

In another aspect, the present invention provides a novel frame structure of packet data to be transmitted over a data network. In particular, according to the present invention, the frame structure comprises a plural number of sequential MAC data frames and only a single PLCP overhead 10.

Preferably, the plural MAC data frames comprise a single concatenated MAC header indicating the plural number as well as the length of MAC data frames.

In a preferred embodiment, if the plural MAC data frames are transmitted to the same destination, the concatenated MAC header further indicates this common destination, and the MAC header portion in each MAC data frame is a compressed MAC header which does not include a portion indicating the destination. This further increases the network throughput and efficiency.

Preferably, the frame structure does not have a limit on the size of the MAC data frames.

#### Brief Explanation of the Drawings

5           The above and other features and advantages of the present invention will be clearer by reading the following detailed description of the preferred embodiments with reference to the accompanying drawings, in which:

Figure 1 illustrates a typical frame structure of a conventional packet data for transmission over a wireless data network using IEEE 802.11 protocol;

10           Figure 2 illustrates components of the MAC data frame shown in Figure 1;

Figure 3 illustrates a frame structure of an embodiment according to the present invention; and

Figure 4 illustrates a frame structure of another embodiment according to the present invention.

15

#### Detailed Description of Preferred Embodiments of the Invention

According to the present invention, instead of transmitting each MAC data frame 20 with a PLCP overhead 10 including a PLCP preamble 11 and header 12, the MAC transmits the PLCP preamble 11 and header 12 only once before the start of the frame transmission and then transmits remaining frames 20 without the PLCP overhead 10 (i.e., the PLCP header 12 and preamble 11). The PLCP preamble 11 and header 12 are used by all receivers. Each receiver decodes only the MAC frames addressed to itself. This is done with the novel frame structure according to the present invention, which is a concatenated frame format (multiple frames packed into a single frame) as shown in Figure 3.

20

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As illustrated in Figure 3, a plural number of sequential MAC data frames 20, which are queued in the buffers, share a single PLCP overhead 10. This means that except for the first MAC data frame 20, the PLCP overhead 10 is totally eliminated from the succeeding frames 20. Thus, the PLCP overhead 10 is only transmitted once  
5 for all the plural MAC data frames 20. This considerably increases the efficiency and throughput of the transmission for these MAC data frames 20, since the PLCP overhead 10 is always transmitted at the lowest rate. For example, if there are ten MAC data frames 20, the overall transmission time for these MAC data frames 20 will be reduced by nine 9 times the single PLCP overhead 10 transmission time. The  
10 single PLCP overhead 10 transmission time is typical 20 microseconds for IEEE 802.11 a or 802.11g, or 192 microseconds for IEEE 802.11b.

Preferably, the plurality of MAC data frames 20 further comprises a concatenated MAC header portion 24, which provides information regarding the number of the frames 20 following the PLCP header 12 and its length, so that the  
15 receivers will know when the MAC data frames 20 start and end. Only one concatenated MAC header 24 is needed at the beginning of the concatenated frames 20.

The number of the MAC data frames 20 following the single PLCP overhead 10 are preferably determined with consideration of the stability of the channel state. In  
20 the case where a concatenated frame 20 is too long, it would be harmful for that frame 20 if the channel stage changes. Based on the estimation of the future channel state during the transmission of the concatenated frame 20, the transmitting station may insert a PLCP preamble 11 after few frames 20 so that the receiver using the channel state information from the preamble 11 can extract the frame if the channel were to go  
25 bad during the transmission.

Figure 4 illustrates another embodiment of the present invention, in which the plural number of MAC data frames 20 are transmitted to the same destination. In this embodiment, the concatenated MAC header 24 further indicates the common destination, while the MAC header 21 in each MAC data frame is compressed. The compressed MAC header 21a only includes certain fields particular to each MAC frame 20, such as a Frame Control field 211, Sequence Control fields 213, etc, and does not include the portion indicating the common destination. Thus, the size of each MAC frame 20 can be reduced, which further increases the network throughput and efficiency as compared to the embodiment in Figure 3.

10            Though the above has described the preferred embodiments in detail, it shall be appreciated that, without departing the spirit of the present invention, various changes, adaptations and amendments are possible to a skilled person in the art. For example, preferably the size of the MAC data frames 20 is not limited to 2304 bytes as required by the current IEEE 802.11 standard, so the network throughput may be  
15   further improved. Moreover, the present invention is not limited to the wireless data network environment using IEEE 802.11 protocol, it is also applicable to any physical media with any MAC protocol. Thus, the protection scope of the present invention is intended to be solely defined in the accompanying claims.

What is claimed is:

1. A method of transmitting data frames over a data network, comprising a step of transmitting a plural number of MAC (Media Access Control) data frames with only a single PLCP (Physical Layer Control Procedure) overhead.
2. The method of claim 1, wherein said PLCP overhead comprises a PLCP preamble and a PLCP header.
3. The method of claim 2, wherein said MAC data frames comprise a concatenated MAC header indicating said plural number.
4. The method of claim 3, wherein said concatenated MAC header further indicates a length of said plurality of MAC data frames.
5. The method of claim 4, further comprising a step of inserting said PLCP preamble after transmission of some of said plurality of MAC data frames.
6. The method of claim 4, wherein said PLCP overhead is sent with a first one of said plurality of MAC data frames.
7. The method of claim 2, wherein each of said plurality of MAC data frames comprises a MAC header portion, a MAC frame body portion and a CRC (Cyclic Redundancy Check) portion.
8. The method of claim 7, wherein said plurality of MAC data frames are addressed to a common destination, said concatenated MAC header further indicates said destination, and said MAC header portion in each data frame is a compressed MAC header that does not include a portion indicating said destination.
9. The method of claim 1, wherein said data network is a wireless data network.

10. The method of claim 9, wherein said wireless data network uses IEEE 802.11 protocol.
11. A frame structure of packet data for transmission over a data network, comprising:
- 5           a plural number of MAC (Media Access Control) data frames;  
and  
          a PLCP (Physical Layer Control Procedure) overhead including a PLCP preamble and a PLCP header,  
          wherein only a single one of said PLCP overhead is provided to all  
10       said plurality of MAC data frames.
12. The frame structure of claim 11, wherein said single PLCP overhead is provided in front of a first one of said plurality of MAC data frames.
13. The frame structure of claim 12 wherein said MAC data frames comprise a concatenated MAC frame header indicating said plural number.
- 15       14. The frame structure of claim 13 wherein said concatenated MAC header further indicates a length of said plurality of MAC data frames.
15. The frame structure of claim 14 wherein said concatenated MAC header is located between said PLCP overhead and said first one of said plurality of MAC data frames.
- 20       16. The frame structure of claim 12 wherein each of said plurality of MAC data frames comprises a MAC header portion, a MAC frame body portion and a CRC (Cyclic Redundancy Check) portion.
17. The frame structure of claim 16 wherein said concatenated MAC header indicates a common destination of said plurality of MAC data frames, and said

MAC header portion in each of said data frames is a compressed MAC header that does not include a portion indicating said common destination.

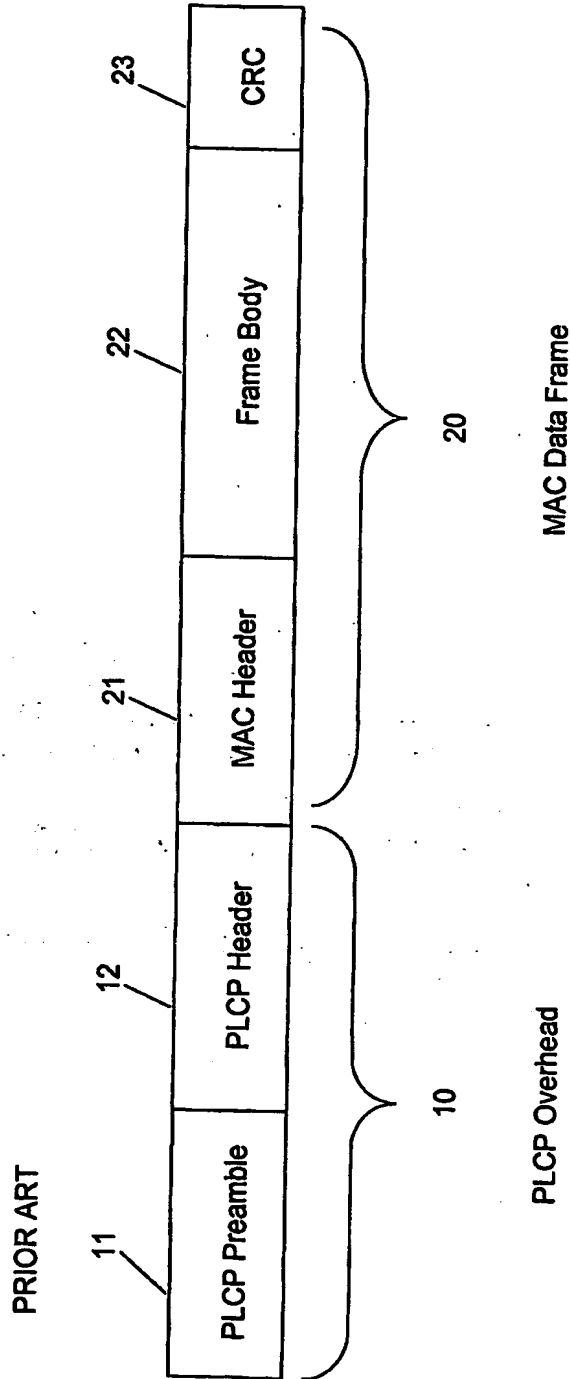
18. The frame structure of claim 17 wherein said data network is a wireless data network.

5 19. The frame structure of claim 18 wherein said wireless data network uses IEEE 802.11 protocol.

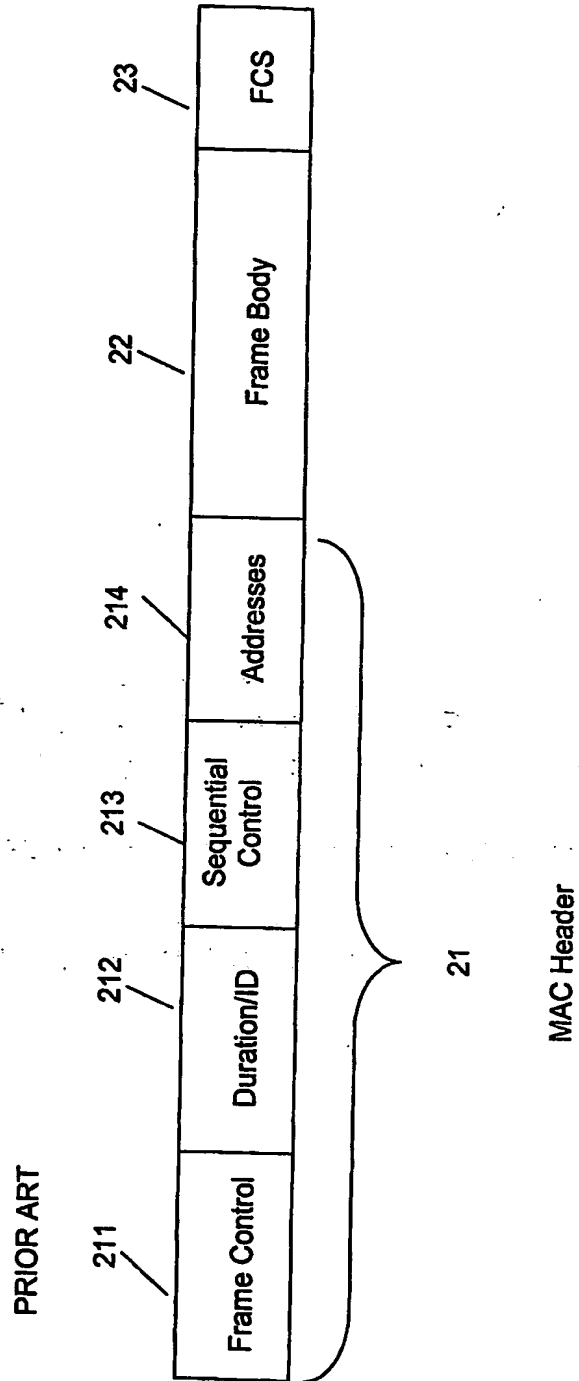
### **Abstract**

**A method of transmitting data frames over a data network with a MAC protocol, such as a wireless network using IEEE 802.11 protocol, in which a plural number of MAC (Media Access Control) data frames are transmitted with only a single PLCP (Physical Layer Control Procedure) overhead including PLCP preamble and header. In the frame structure used in the method, a single concatenated MAC header is added to the plurality of MAC data frames.**

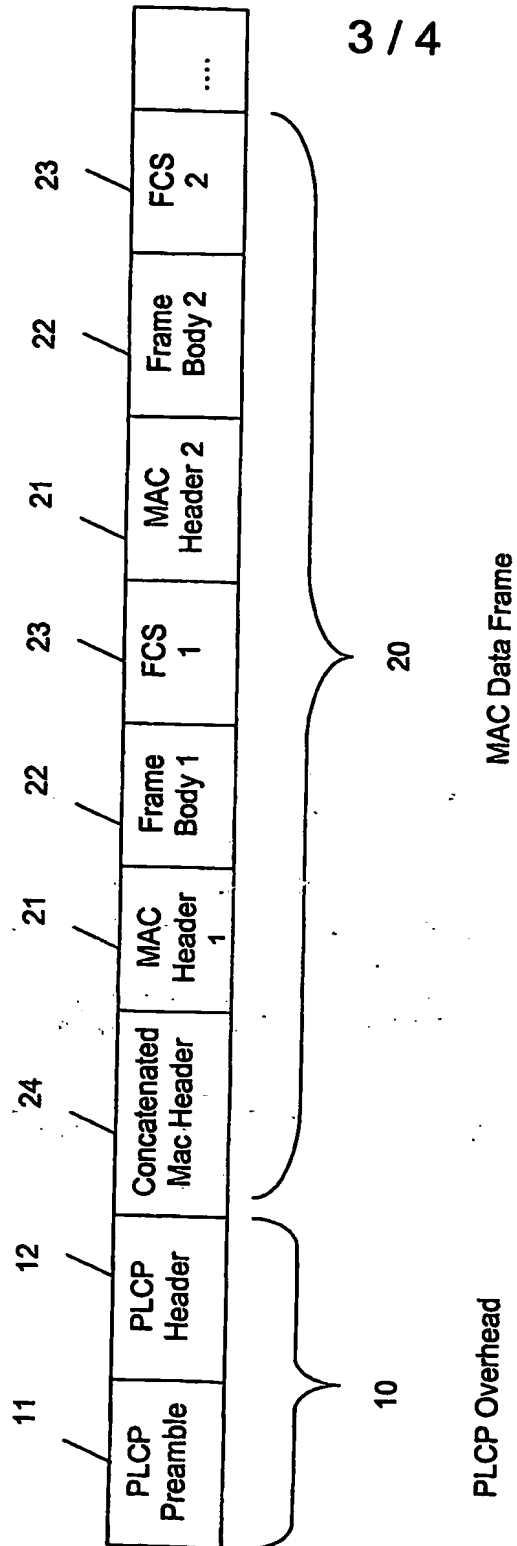
**FIG. 1**



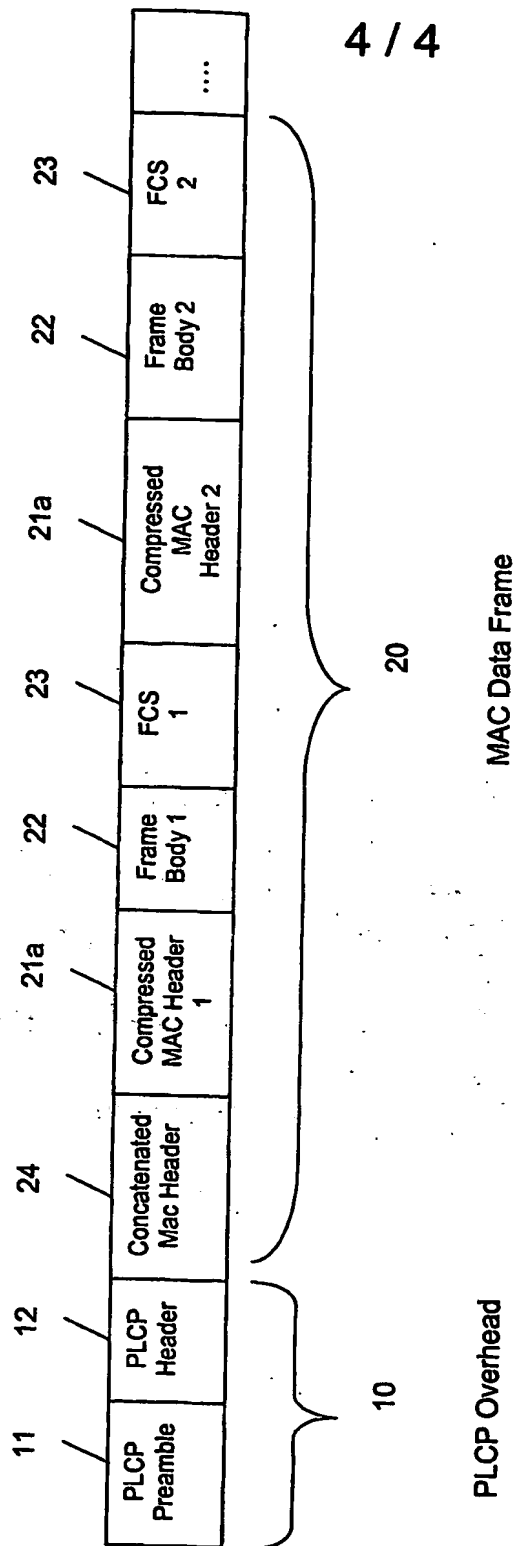
**FIG. 2**



**FIG. 3**



**FIG. 4**



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